THE DEVELOPMENT OF AN INTERACTIVE MATHEMATICS APP FOR MOBILE LEARNING

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ABSTRACT

Low achievement in mathematics education has been an increasing problem in the recent years in some countries. According to a 2010 study from the U.S. Department of Education, blended learning classes produce statistically better results than their face-to-face. There is also an increasing number of students using smartphones and tablets in schools. Mobile devices gained popularity as an educational tool and there are many schools that use them frequently in educational activities to improve learning. In this paper, we present the development of an application for smartphones and tablets to provide activities that students can do outside the classroom or at home and increase the time they spend learning and practicing mathematics. With this app students solve mathematic activities and are helped by the presentation of videos with the problems resolutions.

KEYWORDS

m-learning, mathematics, gamification, multimedia, mobile devices.

1. INTRODUCTION

Low achievement in mathematics education has been an increasing problem in several countries.

For example in Portugal, in 2014, the average classification in the 12th grade exam, from 0-20, was of 7.8. Mathematics exams in the 1st cycle, 2nd cycle and 3rd cycle had an excessive percentage of negatives (levels 1 or 2), 36%, 54% and 47%, respectively.

According to a 2010 study from the U.S. Department of Education, blended learning classes produce statistically better results than their face-to-face. B-learning combines face-to-face instruction with online learning and has yielded strong results since officially being researched as an education model. An advantage of this approach is that it increases the flexibility and individualization of student learning experiences, and it also allows teachers to expand the time they spend as facilitators of learning.

The recent availability of smartphones and tablets with increased processing power and usability, accessible on a large scale, allow an exponential expansion of social and participative web technologies.

It is also important to note that these students are the generation of digital games and social networks. We cannot ignore that they are no longer the same for which the education system was designed a few decades ago. See, for example, the prospect of Heide and Stilborne (2000), for whom "the technological revolution has produced a generation of students who grew up with multidimensional and interactive media sources. A generation whose expectations and world views are different from those that preceded it" (p. 27).

In this context it is wise to consider the integration of digital media and mobile devices (tablets, phablets, smartphones), allowing students to set personal goals, to manage educational content and to communicate with others in the right context.

According to Fernandes and Ferreira (2012), the use of information technology made many changes in the way of teaching and learning. The use of mobile devices that are widely available is also giving the opportunity to students and teachers to change the teaching/learning process.

In this paper, we present the design and development of a mobile application for the teaching and learning of mathematics. Students can use this app in the classroom or outside the classroom in a blended learning model to solve problems. When students have difficulty in solving a problem they can watch the resolution of it. In this way, we want to provide the same opportunities to low-achieving students that may struggle to

learn the materials covered in class. Students have also access to complex problems that may provide additional stimulation for top performers students. In this way, we can provide a platform that is capable of accommodating students with different mathematic skills.

2. MOTIVATION

Results from the 2012 Program for International Student Assessment (PISA), show that Norway, Portugal, Spain and Turkey are below the OECD average in mathematics, with a mean performance of 489, 487, 484 and 448 score points.

The countries that show significant improvement in PISA performance – Brazil, Germany, Greece, Italy, Mexico, Tunisia and Turkey – are those that manage to reduce the proportion of low-achieving students. In Norway, Portugal and Spain about one out of four students, in Turkey about one out of two students, still do not attain the baseline proficiency Level 2 in mathematics. It means that in the best of the cases, low achievers students can extract relevant information from a single source and can use basic algorithms, formulae or procedures to solve problems involving whole numbers.

The PISA report also concludes "improvement in performance rarely comes at the expense of equity in education". There are exceptions to this. "Between 2003 and 2012, Poland and Portugal increased the proportion of high performers in mathematics as they simultaneously reduced the proportion of low performers. Improvements in mathematics performance in Mexico, Tunisia and Turkey, all of which scored well below average in their first PISA tests, are observed mainly among low-achieving students. This usually means greater equity of education opportunities in these countries too. " (OECD, PISA in Focus 2015/01. pp.4).

Regardless the controversy over PISA tests results, this situation calls for actions aiming at improving instruction strategies for teaching and learning mathematics.

In this paper it is presented a mobile app that is looking for improving mathematical performance and achievements for all students including also those in the PISA share of low achievers and the top performers.

The development of this mobile application plans to extend traditional learning environment to a virtual classroom setting that will keep students connected for learning mathematics by the exploration of motivating math tools that will enable students to practice more. This application enables the exploration of video lectures and gamification in smartphones, phablets or tablets.

We want to take advantage of mobile devices for teaching and learning. The recent availability of smartphones and tablets with increased processing power and usability, accessible on a large scale, allow an exponential expansion of social and participative web technologies. However, in many countries teachers and students do not use mobile devices for teaching and learning purposes. It is also important to note that these students are the generation of digital games and social networks. In this context it is wise to consider the integration of digital media and mobile devices (iPad, iPod, tablets, smartphones), allowing students to set personal goals, to manage educational content and to communicate with others in the right context. However, according to the EU Commission initiative Opening Up Education (25 September 2013), between 50% and 80% of students in EU countries never use digital textbooks, exercise software, podcasts, simulations or learning games. Most teachers at primary and secondary level do not consider themselves as 'digitally confident' or able to teach digital skills effectively, and 70% would like more training in using ICTs.

This application will contribute for the implementation of a blended model for teaching and learning mathematics that will accommodate gaming mechanics that it is two-fold: complexity and detail. It has three different levels of problems complexity: beginners, intermediate and advanced. On the other hand each problem has two levels of explanations/resolutions: detailed and concise.

In this way, all students are accommodated in a learning environment centered in the student. The low-achieving students that may struggle to learn the materials covered in class, can study and repeat the materials as many times as they may need to learn. Students will have access to complex problems and activities that may provide additional stimulation for top performers students. Teachers will also be more confident to give homework activities to their students. It is known that it is important to assign homework, to help struggling or underachieving students to learn the material covered in class, to ensure that the material is stored in students' long-term memory, or to provide additional stimulation for high performers. But homework can be particularly burdensome for disadvantaged students. Their parents' may not have the skills

to help them, they may not have the resources to support them on private lessons. We aim at providing the same support for all the students so that we can contribute to weaker the relationship between students' socio-economic background and mathematics performance.

3. MOBILE LEARNING: THEORETICAL FOUNDATION

Technological development influences culture and, through culture, educational theories and practices. For the five past centuries cultural evolution was formed by print technology introducing and establishing a paper textbook as a dominant medium of instruction. With the advent of digital technology, new directions of social and cultural change appeared. Global computer network gave rise to a Networked Society. Mobile computing devices gave rise to a global Mobile Society. Mobile-Social Revolution of the 2000s brought a growing interest in the relations between mobile technology and learning. It is argued that mobile learning is not about 'mobile' nor about 'learning'. It is a part of a new mobile conception of society (Traxler, 2007). Rapid development of mobile technologies has challenged the position of the print textbook-based education. "More and more young people are now deeply and permanently technologically enhanced, connected to their peers and the world in ways no generation has ever been before. […] More and more of what they need is available in their pocket on demand" (Prensky, 2010, p. 2). Access to information through mobile handheld devices has become everyday experience in personal, social and working lives. In this new landscape of mobile lifestyle, education has to respond to portable devices. "Educational institutions must now appropriate personal technologies – the mobile phone […] partly due to student demand for mobile access and partly because these tools facilitate interactions that can support educational ends" (Kukulska-Hulme and Traxler, 2013, p. 245).

Researchers point to numerous benefits of mobile education for both learners and education systems nationally and internationally. By the means of pocketed devices learners are able to break free of the classroom. This introduces change in the mainstream schooling experience and provides opportunity for learning with other learners who are not gathered in the same location. By this attribute, learning with mobile devices allows to "blur the boundaries that neatly enclosed traditional classroom and learning institutions". This quality builds one of the dimensions of the concept of New Learning" (Kalantzis and Cope, 2008, p. 9) as well as responds to the challenge of changing skills in the Knowledge Society.

Use of mobile devices promotes social aspects of learning. Sociability enabled by smartphones supports the creation of mobile communities of practice (Kietzmann et al, 2013). Engagement in communities of practice embeds social participation into learning process. "We are social beings. Far from being trivially true, this fact is a central aspect of learning" (Wenger, 2008, p.4). Possible contribution to collective advancement of knowledge places mobile learning in the perspective of Knowledge Building theory (Bereiter & Scardamalia, 2003).

Mobile technologies support flexible, accessible and personalized education. By using personal technologies learners can build knowledge whenever the need appears. This assists the development of a culture of lifelong learning. With mobile access to learning content, learning can happen in everyday and unconventional contexts, which promotes life-wide learning (Kukulska-Hulme, 2010). Due to the attributes of mobile devices, mobile learning can be ubiquitous and situated (Sharples et al, 2007, pp 224-47).

Mobile computing devices enable access and interaction with media-rich resources, which places mobile learning in the framework of Multimedia Learning theory (Mayer, 2009). Through their functionalities, mobile computing technologies enable creation of digital resources. Through such engagement, learners become active participants in their learning process and creative producers of learning content. This is an obvious advantage over being a passive recipient of information.

The nature and possibilities of mobile learning has been explored for over a decade now. Yet the "design for mobile learning is still at the crossroads" (Kukulska-Hulme and Traxler, 2013, p. 245). Increasing diversity of mobile devices makes m-Learning need resources within educational institutions. In the light of widespread use of mobile devices, mobile learning appears a serious option for education, not only within informal venues but also within formal educational establishments. For this, developing mobile-friendly content and creating mobile learning opportunities appears crucial to the development of educational approaches that meet standards of relevance to the contemporary socio-cultural landscape.

ISBN: 978-989-8533-49-4 © 2016

4. APLICATION DESIGN AND IMPLEMENTATION

This section describes the design and development of the mobile application that students use to study mathematics.

The application is powered by a web server and a relational database management system to store and query the data about users, worksheets of problems and relations between them (Figure 1). Each worksheet includes a set of questions of a selected theme, chapter and grade (year) of the mathematics curriculum. Information about users activities is also stored in the database such as the date and time of the login, selected worksheets and submitted answers.

The web server provides the back office platform that enables teachers to upload questions, instructions for the evaluation and videos. It also allows users with mobile apps to login, access worksheets of problems and videos and upload answers.

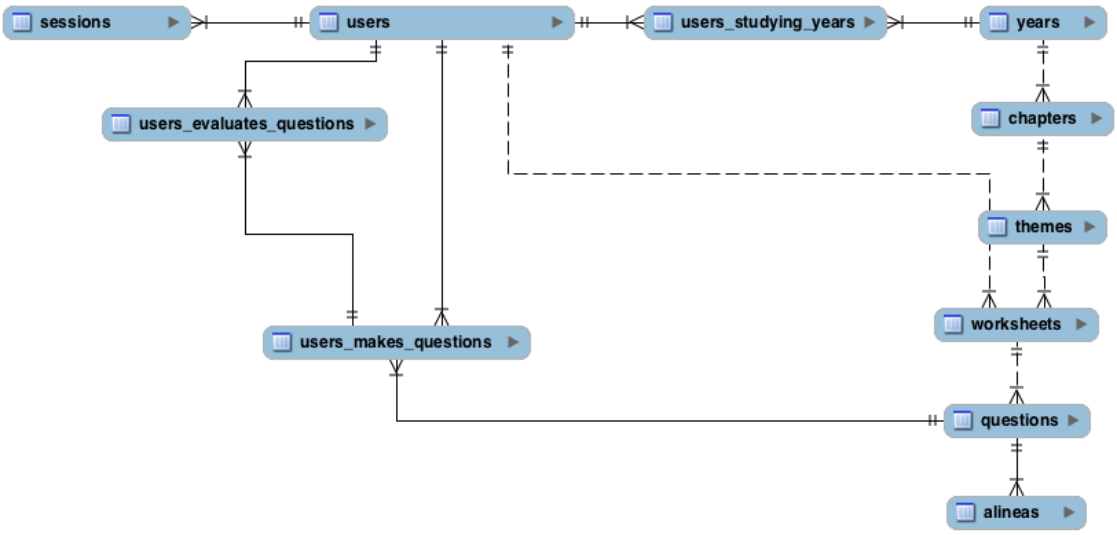

Figure 1. Relational database structure to support the mobile application

Teachers can use a back office page that is accessed through the browser to upload the questions (Figure 2). In an intuitive interface the teacher uploads for each question the year, the chapter, the theme and the worksheet of the problem. Then the different sub-questions are defined. For each sub-question the teacher chooses if it is a multiple choice or open sub-question, the number of points, the instructions for the evaluation and two videos, detailed and concise, with the resolution of the sub-question.

In this way, the teacher creates the worksheets of problems that students have to do to practice the mathematic problems using the mobile device. These problems are uploaded to the server. This data is later available to the mobile app where students have access to the different questions and the videos with the problem resolutions.

This also enables teachers to produce the contents and make them available to their students. An alternate way to produce mathematic activities and problems is to use the textbook companies provided materials, when lecture videos are provided, and exercises that are readily available for teachers and can be uploaded in this platform.

In this way, teachers can use their own produced materials or textbook companies contents to create their own activities targeted to the particular needs of each class and individual student. We believe that this can be very motivating for students and it also helps in delivering lectures, hands-on activities and customized study modules. This is a main advantage of this platform for education because teachers can tailor activities to each student.

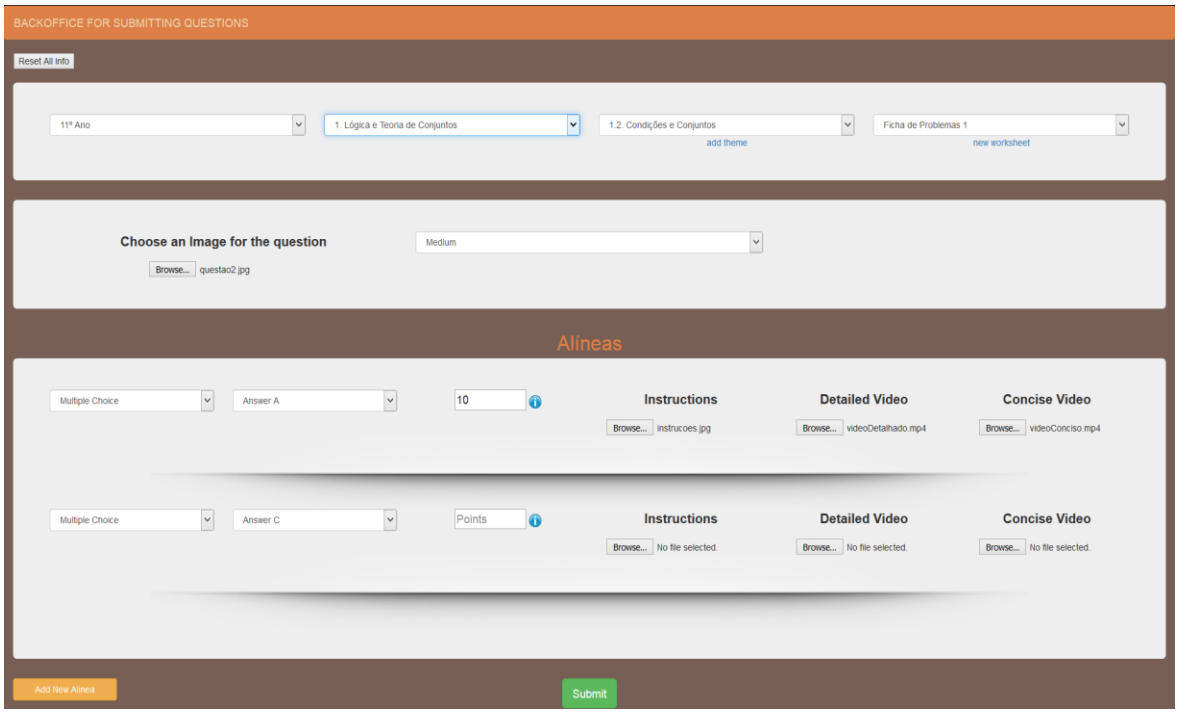

Figure 2. The teacher uploads worksheets of problems with instructions for evaluation and videos resolutions

Students use the mobile app in a smartphone or a tablet to solve the worksheets of problems that were made available by the mathematic teacher. After making the login the student has to choose the worksheet of problems that he wants to solve (Figure 3). Each worksheet of problems relates to the year, chapter and theme of the mathematic curriculum from the 10th to the 12th grade.

After selecting the worksheet of problems the students starts solving questions (Figure 4). At this point it is shown a question at a time. If the question is a multiple choice, the student selects the right answer in a very straightforward way and the app can automatically identify if the answer if correct or wrong.

When the question is an open question then the student makes the resolution and takes a picture, using the mobile device, which is uploaded to the server for later evaluation by the teacher, himself and one of his peers, another student.

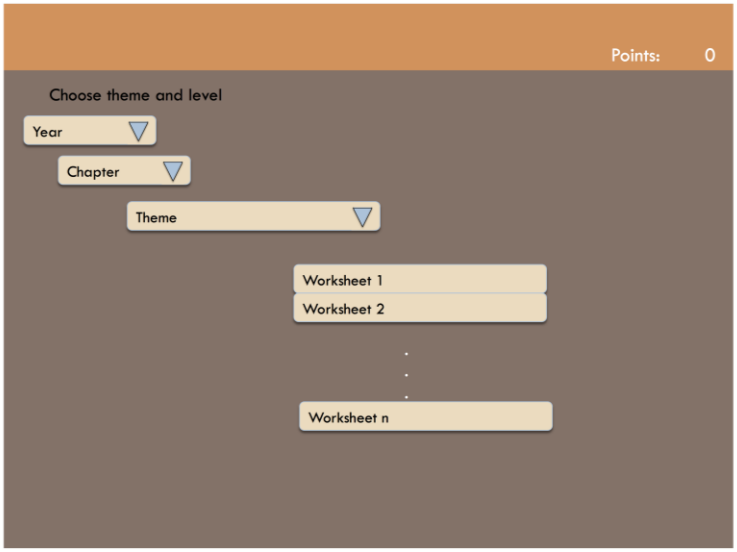

Figure 3. The student chooses the level to play. He plays by solving worksheets of problems

When the student finds it difficult to solve the problem, he can access to the videos with the problem resolutions. The video with the resolution of the problem is well suited for teaching problem solving. It allows students to learn at their own pace and in their own learning style. The videos with the problems resolutions are well adapted for classes with students who have different levels of knowledge of the subject. There are students that can view the materials once and have a good understanding of the mathematical problem. Other students can view the videos several times to better understand the subject. This is an advantage over the traditional classroom where many times the students do not understand and do not ask to repeat the subject until they are able to understand. The use of videos for teaching and learning is effective for both visual and auditory learners as there is video and narration that is less complicated than written explanations (Spilka and Manenova, 2013).

With the number of students increasing in the class this is an important tool to enable students to work at home and leave classroom time to implement problem based learning methodologies together with virtual learning classrooms.

The use of this application also enables to register the student specific achievements in the user database. This data can be later used by the teacher to understand the students' achievements.

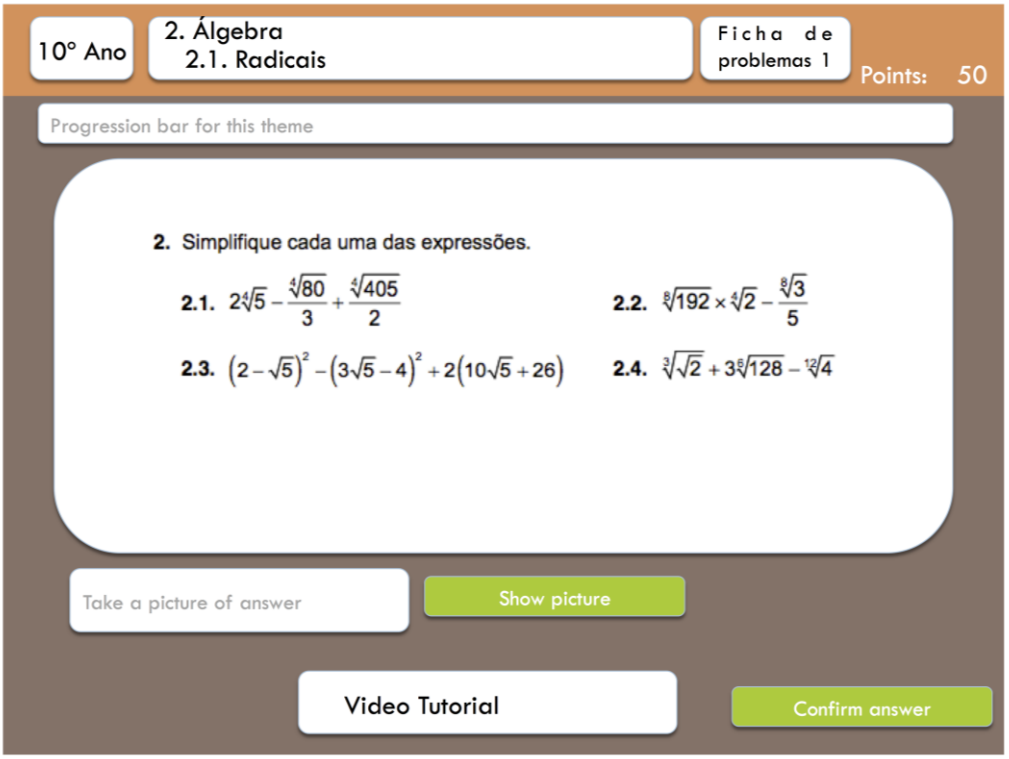

Figure 4. The student solves problems from the worksheet. He earns points each time that he has correct answers

The app presented in this paper let teachers extend the class into a virtual class in a form of blended learning in which students can view video lectures and solve problems outside the classroom. This can be especially interesting for learning mathematics. If students can learn at home from watching video lectures and solving problems, time in-class can be dedicated to explore more motivating problem solving. Math teachers have a difficult situation. Studying math is many times a cumbersome task. But this can be changed if the teacher takes advantage of the technology that is currently available in the classroom. Students are surrounded by multiple devices, such as smartphones and tablets, which give them access to multiple media that is easily available. This is an opportunity for the teacher. The technology related to teaching/learning will have a vital role in the coming years in the education field.

5. CONCLUSION

The increasing processing power of mobile devices and the increasing number of mobile devices, makes possible the use of these devices for educational purposes.

Math teachers have a difficult situation. Studying math is many times a cumbersome task. Low achievement in mathematics education has been an increasing problem in the recent years in several countries has seen in the 2012 PISA results.

In this paper, we show the development of an interactive mobile application to make available mathematic problems and the videos of problem resolutions enabling the expansion of the classroom into a virtual space where students can have more time practicing problem solving.

We show that technology is accessible and easy to use by math teachers and students.

ACKNOWLEDGEMENT

We would like to thank the support to Project "MILAGE-MathematIcs bLended Augmented GamE" (N.º2015-1-PT01-KA201-012921), from Erasmus+ program, funded by the European Union.

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